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松果腺腫瘍ノ外科ニ關スル批判的考察

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Surgical Removal of Pineal Tumors.

A Critical Review of the Literature.*

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【内 容 和 文 抄 錄】

松果腺腫瘍ハソノ解剖學的關係上手術的剔出ノ最モ困難ナルモノナリ。著者ハ從來提唱サレ來レル諸手術々式及ビソノ成績ヲ文獻ニ就テ考察セリ。文獻ニ現ハレタル松果腺腫瘍ノ手術剔出例20，同一經路ニヨリテ手術セラレタル第三腦室腫瘍例16アリ。手術死亡率約40%，一見甚ダ悲觀的ナルガ如キモ，結果甚ダ良好ニシテ激勵的ナル例モ尠カラズ。㆑松果腺腫瘍ハ他ニ有效ナル方法ナキ以上當然外科的ニ處置スベキモノナリ㆒ト斷言セシムルニ足ル。尙文獻例ヨリ考察シテ手術技術上ノ2,3ノ點ニ就テ著者ノ意見ヲ述ブ。（自抄）

In the present paper a thorough review of the literature may be made, regarding the study of pineal surgery, which is still in its developmental stages.

Operative approaches to the pineal region.

In 1913 three different approaches to the pineal region were published by Krause, Nasetti and Brunner respectively.

In Krause's posterior approach[1) 2)], the cerebellum was bilaterally exposed, extending above the lateral sinuses. The tentorium was retracted upward from the upper surface of the vermis with an elastic spatula, whereas the cerebellum was pushed downward. During this procedure several veins running from the upper surface of the vermis up to the sinus rectus were encountered. Three such veins were in his case doubly ligated and divided. Accidental injury to these thin-walled vessels is apt to cause diffuse bloody infiltration in the local arachnoid meshes in addition to troublesome bleeding, thus disturbing the topographical orientation.

Proceeding in this way beyond the anterior end of the vermis, the posterior portion of the quadrigeminal bodies is seen as a bluish shimmering bulging, due to the covering of the

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1) Oppenheim, H. and Krause, F. Operative Frfolge bei Geschwülsten der Sehhügel und Vierhügelgegend. Berl. Klin. Wchnschr. 1913, **50**: 2316—2322.

2) Krause, F. Operative Freilegung der Vierhügel, nebst Beobachtungen über Hirndruck und Dekompression. Zbl. f. Chir. 1926, **53**, 2812—2819.

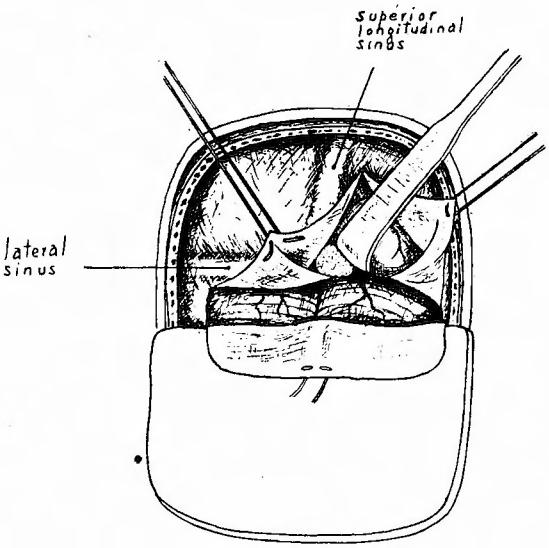
arachnoid membrane. The distance from the posterior surface of the cerebellum to the posterior margin of the quadrigeminal bodies is about 6 cm.

Using this approach Krause exposed the quadrigeminal region in three cases, being successful in the removal of the tumor only once, in which case the tumor proved to be of quadrigeminal and not of pineal origin. All three patients survived and recovered well.

As Krause himself pointed out, the chief disadvantage of this approach lies in the technical hazard of accidental injury of large veins between the cerebellum and sinus rectus. As another probable disadvantage McLean[3] states that most pineal tumors present into the incisura from above, thus making the manipulation from below the impaction extremely difficult. On the other hand Van Wagenen[4] regards the posterior approach to be disadvantageous for just the opposite reason that most pineal tumors do not extend posteriorly so that the tumor cannot be reached from behind at a reasonable depth.

Fig. 1

Puussep's bilateral occipitosuboccipital approach.



At any rate the great majority of recent neurosurgeons are agreed in regarding the posterior approach as being impractical. Dandy[5] once tried to remove a pineal tumor by the posterior approach and, although the tumor was found, it was entirely inaccessible for removal, thus necessitating a reoperation on this case by his transcallosal approach ten days later.

Puussep[6] (1914) operated on a pineal tumor by a bilateral occipitosuboccipital exposure (Fig. 1), in which he removed the bone from about 5 cm. above the protuberantia occipitalis externa down to the suboccipital region. A dural flap was turned down to expose both hemispheres of the cerebellum, and after doubly ligating and dividing the right lateral sinus the dural incision was extended upward parallel to and 2 cm. apart from the superior longitudinal sinus, then the tentorium was also divided parallel to the rectus sinus through its entire extent.

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3) McLean, A. J. Pineal teratomas. Surg. Gynec. and Obst. 1935, **61**, 523—533.

4) Van Wagenen, W. P. A surgical approach for the removal of certain pineal tumors. Report of a case. Surg. Gynec. and Obst. 1931, **53**, 216—220.

5) Dandy, W. E. An operation for the removal of pineal tumors. Surg. Gynec. and Obst. 1921, **33**, 113—119.

6) Puussep, L. Die operative Entfernung einer Zyste der Glandula pinealis. Neurol. Cbl. 1914, **33**, 560—563.

Ample room was thus made to gain access to the pineal region by retracting the falx medially, the cerebellum downward and the right occipital lobe laterally. A cystic tumor was disclosed in the depth of the operative field and was incised in order to evacuate the contents. Then an attempt was made to shell out the entire cyst wall by finger dissection but proved unsuccessful. The patient died on the third postoperative day.

Nassetti[7] exposed the pineal region through the midline by a wide craniotomy over the parieto-occipital vertex and resecting the longitudinal sinus, the falx and sinus rectus. The cerebral hemispheres were retracted bilaterally and the posterior portion of the corpus callosum was transected in the midline, thus exposing the pineal body.

This approach would be ideal for purposes of the surgical manipulation in the pineal region, but does not seem to be compatible with life; at least the useful postoperative life of the patient is questionable, because we could never resect at the same time the two highly important venous sinuses—rectus and superior longitudinal—with impunity. Although the resection of the sinus rectus alone does not always jeopardize life, as is shown by one of Dandy's cases[8], the resection of the posterior part of the superior longitudinal sinus would certainly cause a diplegia.

Brunner (1913)[9] attempted to remove pineal tumor by a unilateral transcallosal approach. He turned down a right occipital flap, proceeded through between the falx and the right occipital lobe and planned to transect the posterior part of the corpus callosum in the midline. However, the latter was accidentally lacerated for 4 cm. on retracting the occipital lobe. In this situation he found the field of operation to be too restricted and too deep to go further and gave up the operation without exposing the tumor. In retrospect, he remarked that more room was necessary, which could probably be obtained by splitting the lower margin of the falx after ligating the inferior sagittal sinus.

His description is somewhat too brief to comprehend the technical details of the procedure. But he is apparently the first who attempted to reach the pineal region unilaterally by the transcallosal approach, which has been since then improved upon and used in not a few occasions by recent neurosurgeons.

Brunner's approach was modified by Tandler and Ranzi[7] as follows: Turning down a unilateral parieto-occipital osteoplastic flap, the posterior portion of the one hemisphere is retracted away not only from the falx to one side, but also upward from the tentorium. To obtain additional room, they advised the splitting of the tentorium on one side as extensively as necessary from the anterior free margin parallel to the rectus sinus and then transversely to it so as to turn away a flap of the tentorium laterally. They hoped thereby to remove a pineal tumor

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7) Tandler, J. and Ranzi, E. Chirurgische Anatomie und Operationstechnik des Zentralnervensystems. Berlin, J. Springer, 1920, 126—130.

8) Dandy, W. E. Operative experiences in cases of pineal tumor. Arch. Surg. 1936, **33**, 19—46.

9) Rorschach, H. Zur Pathologie und Operabilität der Tumoren der Zirbeldrüse. Beitr. z. Klin. Chir 1913, **83**, 451—474.

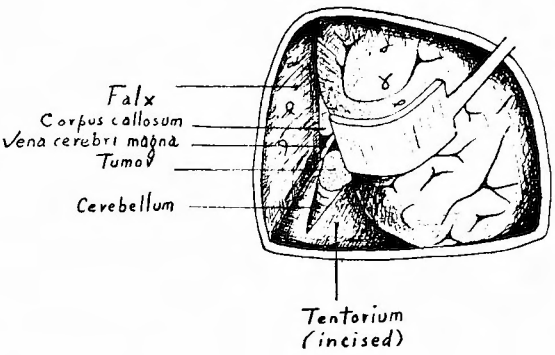
without dividing the corpus callosum in order to avoid the probable defect in mentality which might follow the injury to the corpus callosum.

This procedure seems to have been worked out on a cadaver, because no case has been reported by them in which they actually removed or attempted to remove a pineal tumor in this way.

It was not until Foerster[10] that a pineal tumor was successfully operated on by Tandler-Ranzi's method, which was, however, somewhat modified by him. He described the method as follows : An osteoplastic flap is made over the posterior half of the right cerebral hemisphere. The dura is incised in a triangular form. All veins running from the parieto-occipital cortex to the longitudinal as well as to the lateral sinus are ligated and divided. The occipital lobe is then retracted from the falx to one side and upward from the tentorium (Fig. 2). Incisions

Fig. 2

Tandlar-Ranzi's approach, modified by Foerster.



are made both into the tentorium parallel to the rectus sinus and into the lower margin of the falx. For the removal of a pineal tumor he divides the splenium of the corpus callosum in the midline for a distance of several centimeters.

He had three occasions to expose the pineal region in this way, but was successful in the removal of a tumor only in one instance.

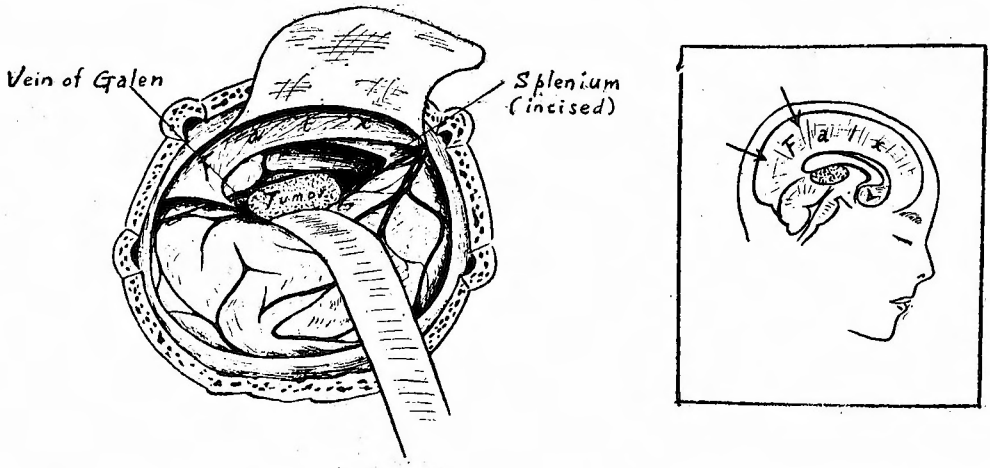
In 1915, a little later than Brunner but much earlier than Tandler-Ranzi and Foerster, Dany[11] published his pineal approach in dogs, in which he proceeded in almost the same way as Brunner, but he preferred a parieto-occipital flap a little more anterior than Brunner's. He deemed that the elevation of the occipital lobe from the tentorium was unnecessary. Six years later he succeeded in removing a pineal tumor in man without immediate death by this procedure (Fig. 3) and emphasized the possible operability of pineal tumors. The description of his approach is as follows :

10) Foerster, O. Das operative Vorgehen bei Tumoren der Vierhügelgegend. Wien. Klin. Wchnschr. 1928, **41**, 986—990.

11) Dandy, W. E. Extirpation of the pineal body. J. Exper. Med. 1915, **22**, 237.

Fig. 3

Dandy's unilateral posterior transcallosal approach.



"The approach to the tumor is made possible by a very large parieto-occipital bone flap, the medial margin of which extends to the superior longitudinal sinus.....The dura is then opend and reflected over the superior longitudinal sinus. In doing so, the cerebral veins which bridge the subdural space between the brain and the longitudinal sinus are gradually elevated, doubly ligated and divided. The number of these veins in the necessary field of operation varies from one to six or even more. It is well, if possible, to avoid ligature of the Rolandic vein for a transient hemiplegia will follow. Usually, however, it is necessary to ligate all the veins posterior to the Rolandic vein. It is hardly necessary to add that for this reason and because of possible speech disturbances, the craniotomy should be performed on the right side; and because tumors of the pineal body are always in a strictly central position, exposure of the growth is equally easy on either side.....After division of the cerebral veins the entire posterior half of the cerebral hemisphere can be retracted and the falx exposed. The inferior longitudinal sinus is quickly passed and the corpus callosum brought into view as the brain is still further retracted.....The posterior half of the corpus callosum is then carefully incised in the midline for a distance of 3 or 4 centimeters and the hemispheres still further retracted. The tumor will then be brought into full view. Under the splenium of the corpus callosum the vena Galena magna will always be brought into full view at its entrance into the sinus rectus.....In the first case the tumor stripped readily from the vein.....In the second case the great vein of Galen and each small vein of Galen were divided between silk ligatures.....A great deal of room is afforded by the release of fluid from the lateral ventricle by a puncture early in the operation, thus allowing the reduced bulk of brain to be easily retracted from the operative field. Were it not for the release of fluid not only would the exposure of the tumor be very difficult but the necessary retraction of the brain would be very injurious to the cerebral hemisphere".

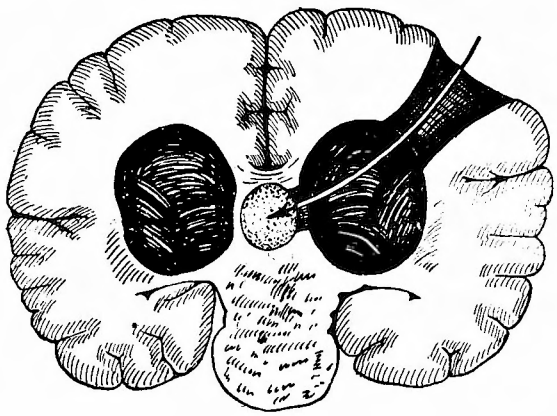
This encouraging report by Dandy seems to have marked the starting point of modern

pineal surgery, despite the fact that a similar procedure had been previously published by Brunner. This type of approach, to be called, the unilateral posterior transcallosal approach or Brunner-Dandy's approach, is becoming more and more common. Most cases of pineal tumor reported in the recent literature have been operated on by this approach.

In 1931 another rational approach to the pineal region, which is usually called a transventricular approach, was proposed by Van Wagenen[4]. Since pineal tumors are almost always accompanied by a hydrocephalus and since they bulge more or less into the lateral ventricles as is seen in Fig. 4, an approach through one dilated lateral ventricle can easily be comprehended.

Fig. 4

Schematicd representation of Van Wagenen's transventricular approach.



He described his method as follows:

"A right parieto-occipital bone flap. A reversed L-shaped incisions 6 to 7 centimeters long was made in the cortex extending from the posterior end of the superior temporal gyrus upward and slightly backward ending at the lobulus parietalis superior. The incision was carried downward into the ventricle. The point of entering the ventricle was at the juncture of the temporal and occipital horns of the lateral ventricle. A distinct bluish bulge was to be made out in the depth of the wound. This was covered by the much thinned out medial wall of the lateral ventricle and was easily divided and removed. The surface of the tumor exposed was coagulated with the electric cautery and the desiccated portion removed with suitable rongeurs and with the help of a suction apparatus. By repeating this process several times, the tumor was entirely removed except for a small bit adherent to the large adjoining veins".

This approach is believed by Van Wagenen to be "the logical and the least vascular route. The only vessels of consequence that must be ligated before the tumor is exposed are the cortical veins which should offer little difficulty. The tributaries of the great vein of Galen about the tumor can be more casily seen and dealt with inasmuch as such an approach is

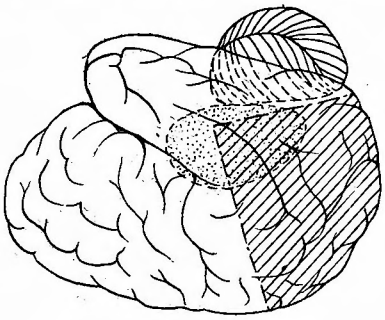
directly down on them. The amount of injury to brain tissue from an incision of the cortex can be no greater than the softening resulting from ligature of veins entering the lateral sinus, which must be done in exposing the third ventricle through the corpus callosum".

The propriety of this rather theoretical opinion should be decided only by operative experiences. The four cases, in which this approach has been employed, at least do not seem to support his contention, because they developed in the postoperative course no fewer untoward sequels than in the cases of transcallosal approach, as will be mentioned later.

In some instances the tumor may be too large to be radically removed by either transcallosal or transventricular approach. An incision in the lower margin of the falx or in the tentorium is not sufficient to obtain adequate room. Furthermore a large tumor develops more rapidly, blocks the aqueduct more promptly and therefore is associated with smaller lateral ventricles, the tapping of which may not provoke the sufficient shrinkage of the cerebral hemisphere to facilitate their retraction with a spatula. Under such circumstances a supplementary procedure was employed by the resection of the occipital and part of the parietal lobe (Fig. 5) first by Dandy[8] and then by Horrax[12]. Since the acutal size of the tumor cannot be exactly prophesied before operation, this resection is not to be done until the tumor really turns out to be unusually large. Thus Dandy had exposed the tumor by his approach and Horrax by a transventricular route, before they did such a resection. Dandy states that "the removal of the occipital lobe is the easiest of all lobe resections, because there are susually no large veins (the veins entering the lateral sinus at the mastoid are avoided) and only the posterior cerebral artery requires ligation .....sacrifice of the right occipital lobe adds more than the necessary room and brings the major part of the tumor directly into view, permitting the operator to use both hands to extirpate the growth.....This method was used in four cases (in three of which the outcome was fatal and in one successful)".

Fig. 5

Shema showing the lines of resection of the parieto-occipital lobes for the removal of a large pineal tumor.



Horrax remarks that "such a resection, of course, commits the patient to permanent left homonymous hemianopia and doubtless, to permanent changes in the sensory sphere involving the left side. The hemianopic defect, however, was permanent in the patients of both Harris and Cairns and Van Wagenen, and operation was performed by the simpler methods. Whether this postoperative feature can ever be avoided is therefore uncertain, but in any event it is compatible with a useful life. The same may be said in regard to the sensory changes which

12) Horrax, G. Extirpation of a huge pinealoma from a patient with pubertas praecox: A new operative approach. Arch. Neurol. & Psychiat. 1937, 37, 385—397.

were likewise present and apparently permanent in the patient of Harris and Cairns, i. e. impairment of postural sensibility and astereognosis".

Operative Results.

Tumors in the pineal region are from a surgeon's viewpoint most unfavorable due to their inaccessible position. Cushing never succeeded in exposing a pineal tumor sufficiently well to justify an attempt to remove it. However, recent reports on pineal surgery are not so discouraging, even though they are, of course, not as brilliant as those concerned with tumors located in other regions of the brain.

Expecting further improvements of operative procedures in this particular field, an attempt will be made in the following to review thoroughly all reported cases of pineal tumors which were operated on successfully or unsuccessfully, from the point of view not only of the immediate results of the operation, but also of the postoperative course, the persisting sequels and of the final outcome of the patients.

In view of the fact that in recent times pineal tumors have been operated on using one of the three approaches, i.e., an unilateral posterior transcallosal (including Foerster's), a transventricular and an approach by the resection of the occipital lobe, our considerations will be confined to these three. Besides that, tumors in the third ventricle, which were operated on by a pineal approach, will be also included in our series for the study of the methods of operation themselves, although the removal of pineal tumors may be more hazardous than that of tumors in the third ventricle because of adhesions to the quadrigeminal plate and of the intimate relations with the veins of Galen in most cases of the former.

Thus twenty cases of pineal tumor and sixteen of tumor in the third ventricle, totaling thirty-six can be found in the literature, in which an attempt was made to remove a tumor from the pineal region or from the third ventricle by the one or the other of the three approaches (Table I). The operative results are summarized in Table 2.

Of thirty-six cases fourteen died in consequence of operation, of which nine died within ten days after operation and five from one to six months later, thus making the operative mortality 38.9%*. The causes of death are reported to be postoperative hemorrhage, pneumonia, surgical shock, acute postoperative cerebral edema, etc. in cases of immediate death, and cicatrix in iter, softening or edema in the operated area and adhesion about the midbrain in cases of later death. Four further deaths, which occurred later than six months after operation, were not due to the operation itself, but to the recurrence of the tumor. On the other hand satisfactory results have been obtained in six cases, in which the patients have survived the operation for

*) This figure may be probably smaller than that of the real mortality, if unavailable cases, in which the operation might be unsuccessful and therefore not reported, are taken into consideration.

more than two years, enjoying a useful life. The other twelve patients survived the operation and were living and well at the time of report, but the time elapsed since operation was less than two years.

Between the group of tumors in the third ventricle and that of pineal tumors we can hardly find any definite difference in regard to the operative results, except that cases of later death are apparently more frequent in the latter group (2 : 7).

As to the procedures of the operation, thirty cases were operated on by a unilateral posterior transcallosal approach (I), four by a transventricular route (II) and two by the resection of the occipital lobe (III). In group I and II the operative mortality is almost the same (30—50%), while in group III there is no successful case.

In order to obtain more exact knowledge of the possibilities of the operation, postoperative sequels may be studied in detail. Although a perfect description of the postoperative can be found in relatively few cases, the gross incidence of postoperative sequels is as follows :

1) Extrinsic and intrinsic ocular muscle palsies are reported in thirteen cases to have appeared or increased in degree following operation. Though in most cases they improve gradually, they usually persist for a long time varying in intensity.

2) Mental disturbances have been described in twelve cases. The patients are drowsy, stuporous or confused, presumably due to the acute increase of the intracranial pressure, and when awakened, they are frequently disoriented for space, time and person and show marked loss of memory for recent events, trying to disguise the defect by confabulation. Sometimes they become talkative and speak in a childish manner. In some cases the mentality was described as sluggish. These mental defects are usually transient and very persistent.

3) Contralateral hemiparesis in ten cases. This is caused for the most part at the time of operation by the mechanical retraction of the parietal lobe with a spatula ; usually transient.

4) Contralateral hemihypesthesia, astereognosis and loss of position sensation in five cases. The cause is apparently the same as that of hemiparesis.

5) Contralateral homonymous hemianopia occurred, in nine cases as the result of retraction of the occipital lobe and not due to the operative injury to the lateral geniculate body. Hemianopia persists permanently in most cases.

6) Transient disturbance of visual acuity in seven cases. In some instances the patients are totally blind for several days after operation. It is believed that the postoperative edema in both lateral geniculate bodies may be the cause.

7) Hyperthermia (40°C. or more) in seven cases. Two of them died shortly after operation and two others died later in the postoperative course.

8) Incontinence of bladder in six cases. This seems to be due mostly to mental disturbances.

9) Loss of hearing for high tones in two cases.

10) Incomplete decerebrate rigidity in one case. There seems to be not much difference

in postoperative sequels whichever of the three approaches is employed, although more serious sequels tend to follow the approach by the resection of the occipital lobe.

11) Transient anomia was noted in one of the cases which was operated upon from the left side.

Reviewing these facts, it may be easily understood that the postoperative sequels on the whole will not handicap to a great extent the pursuing a normal life of the patients. Mental disturbances, hemiparesis, hemihypesthesia, disturbance of visual acuity, and incontinence are all transient, whereas persisting palsies of ocular muscles and homonymous hemianopia are not so disturbing. They are less significant than in cases of tumors injuring the motor or speech areas.

However, in the presence of such a high operative mortality as 40%, or even more, the primary problem in pineal surgery lies in the preservation of the patients' life. In almost all cases, immediately after operation, a high intracranial pressure follows, due to the edema in the operated areas, especially in the vicinity of the aqueduct of Sylvius, damming up the flow of the cerebrospinal fluid. For relief ventricular tapping three or four times a day or ventricular drainage is necessary for several days after operation. The aqueduct can also be blocked at its mouth late in the postoperative course by a cicatrix resulting from operative trauma. Thus Dandy warned against the traumatizing the ependymal lining of the third ventricle, particularly at the aqueduct, so that a large opening in the roof of the third ventricle should be avoided.

Cicatricial adhesions about the midbrain may be another factor in the development of postoperative pressure symptoms, because they cause the obstruction of the fluid pathways at the incisura, preventing the flow of the cerebrospinal fluid from cisterns of the posterior fossa to the subarachnoid space over the cerebral hemispheres. Horrax assumed that these adhesions about the midbrain were a probable cause of death in his case.

With these considerations in regard to the postoperative sequels in mind, we may discuss some points in the operative technique.

1) Ligation of cerebral veins. In reaching the pineal region, several veins connecting the cerebral hemisphere with the superior longitudinal sinus are to be ligated and divided. The number of these veins varies from none to six. As Van Wagenen stated, it is possible that the interruption of these veins might leave some functional deficiency of the corresponding cerebral cortex. In Table 1, we can find nine cases in which it is specifically described that not more than two veins were ligated and divided. Of these, two showed more or less mental disturbances, only one a hemihypesthesia and none a hemiparesis, that is, apparently there were less sequels than in the other cases. Therefore no veins should be ligated other than those which are necessary in performing the operation. This fact, however, does not seem to favor a transventricular approach, because even in cases operated on by this approach, in addition to mental disturbances, marked hemiparesis and hemihypesthesia resulted presumably due to retraction of the cortical wound with a spatula.

2) The sacrifice of the great and small veins of Galen. Both small veins of Galen with or without the great vein of Galen were sacrificed in four cases, in which one patient died in forty-eight hours, two others three months after operation and one survived the intervention. It is to be noticed that in these cases the tumor was large and densely adherent to the surrounding structures, so that not only the division of these important veins, but also the resection of the occipital lobe had to be carried out in two cases to obtain adequate room. Therefore, it is very difficult to tell whether the death was due to the obstruction of these veins or to the greater intervention as a whole. But it is quite encouraging that in one instance the patient has survived the operation for more than six years, a fact which clearly shows that the division of these veins does not necessarily mean the death of the patient.

A small vein of Galen on one side was divided in four cases with no mortality and no particular symptoms. Therefore, one small vein of Galen can be quite safely ligated and divided.

3) The side of approach. The approach from the right side should be theoretically preferred to that from the left for right handed patients. Six cases were operated on from the left with three deaths. There was no particular after effect in mental spheres. Transient and slight anomia occurred only once. Bilateral approach was made in one case with subsequent death.

4) Removal of the tumor by intact dissection or by means of a suction machine. Needless to say, a tumor of the central nervous system is more safely removed by a suction machine than by intact dissection, although the latter may be theoretically more radical and perfect. It may be almost comparable with the evacuation of a cyst, which is far less hazardous than the intact removal of a solid tumor. In five cases the tumor was sucked out. No immediate death, although two patients died three and fifteen months respectively after operation. The result is almost the same as in cystic tumors of the pineal region, in six cases of which there were two later deaths seven months and two and one half years respectively after operation, but no immediate mortality. However, if the tumor is very touch or exceedingly calcareous, a suction machine cannot be used, as is not infrequently the case. But whenever possible, the tumor should be removed with a suction machine rather than by intact dissection. It would be foolhardy to insist on intact dissection even in instances where the tumor can easily be sucked out.

On some occasions a firmer tumor which cannot be sucked out can be at first excavated in its interior by a curette or an electric loop so as to reduce the bulk, and then its outer portion can be shelled out in the next step in identically the same way as is usually done for the removal of meningiomas located in difficultly accessible areas within the intracranial cavity. However, if the tumor is extremely vascular or extensively calcified, a curette or an electric loop cannot be used. Despite the fact that in our series a good postoperative result was not always obtained, it would be safe to advise the procedure, whenever possible, in view of the experiences with meningiomas. The electric loop must be used with great caution in this region because of danger of damage to vital structures at the time and also later of adhesions

from the inflammatory reaction which always follows its use.

5) Transection of the splenium corporis callosi. In Brunner-Dandy's approach, a pineal tumor cannot be removed without transecting the splenium of the corpus callosum. Fortunately no particular symptoms follow this transection, as Dandy emphasizes. However, Tresher and Ford[21] reported a case in which Dandy removed a colloid cyst in the third ventricle by his right pineal approach and following the operation a particular syndrome appeared, for which the transection of the splenium corporis callosi semed to be responsible. This syndrome consisted of the following symptoms:

i) Complete disorientation for time, place and person, with confabulation and euphoria.

ii) Inability to form and retain topographic memories.

iii) Inability to recognize letters of the alphabet (by touch) in the left hand without astereognosis or evidence of cortical anesthesia.

iv) Inability to recognize letters falling in the left visual field, with loss of attention of that side without hemianopia for form or color.

Symptoms ii) iii) iv) persisted for more than four years, although they had become less severe year by year.

It was suggested by them that these symptoms constituted the syndrome characteristic of the posterior part of the corpus callosum, nevertheless its transection in exposing a pineal tumor does not necessarily give rise to this syndrome, because the corpus callosum has been under compression of the tumor for a long time before the operation, thus possibly establishing compensating pathways elsewhere. At least no other case has been reported, in which the same syndrome appeared after operation. Perhaps it was not sought for in the other cases.

Summary.

The operative procedures for the removal of pineal tumors have been reviewed. Most cases reported in the literature were operated upon by a unilateral posterior transcallosal approach, which was proposed by Brunner and Dandy, or by its modifications. In four instances a transventricular approach has been employed. A larger tumor was removed in two cases by the supplementary resection of the parieto-occipital lobes.

Of the tewenty cases of pineal tumors, which were operated on by the one or the other method, four died immediately after operation and four died from one to six months later, thus operative deaths totaled eight, the operative mortality being thus 40%. Three more patients died later on due to recurrence of the tumor. Three patients have survived the operation for more than two years, enjoying a useful life. Six other patients were operated on with success, but the time elapsed since the operation had not reached two years at the time of report.

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21) Tresher, J. H. and Ford, F. R. Colloid cyst of the third ventricle. Report of a case, operative removal with section of posterior half of corpus callosum. Arch. Neurol. & Psychiat. 1937, **37**, 959—973.

Table. I. Tumors of the pineal body and of the third ventricle collected from the literature, which were operated on by pineal approaches.

No.	Case operated on by	Location of tumor	Age	Sex	Nature of tumor	Size of tumor	Operative approach	Method of removal	Result	Time elapsed since operation	Side of approach	Sacrifice of internal cerebral veins	Sacrifice of cortical cerebral veins	Postoperative sequels	Persisting sequels	Remarks
1	Dandy[78] 1933 Group I Case 1	Tumors in the third ventricle	24	F	Colloidcyst	marble		intact dissection	well	4½ yrs.	r	(—)	3	A very stormy course with high temperatu[re] (108 F). Delirious. Partial hemiplegia. A marked mental disturbance. Speaks in [Polish manner, somewhat disso]ciated; for place, person, and completely so for time. Memory for recent events poor, and confabulates. These mental disturbances were attributed to the glutical [disease] which was discovered 17 days after operation.	(—)	
2	" " Case 2		34	F	Colloidcyst	marble		evacuation of cyst, removal of capsule	well	4½ yrs.	l	l-small vein of Galen	several	Uneventful. Feber (99–102) for two weeks.	entirely free from symptoms.	
3	" " Case 5		37	F	Colloidcyst	marble		intact dissection	well	3 mos.	r	(—)	1	A marked mental confusion and disorientation. A marked loss of sense of space and some astereognosis (l-hand).	Sequels almost entirely cleared. Participated in a golf tournament.	This case was reported by Fischer and Fogel.[81]
4	Dandy 1933 Group II Case 2		6	F	Ependymal glioma	almond		intact dissection	well	6 yrs.	r	both small veins of Galen	(—)	Vision worse than before operation. Almost blind for a time. 26 days after operation the left eye totally blind. The right blind for colour and a greatly reduced field for form. A definite external squint in the l[eft] eye.	Reve[rse] greatly improved. Field for form fairly normal. L-eye; only light perception. Sweet natured, normal school child.	Cere[bellar] exploration 35 days prior to the operation.
5	" " Case 3		12	M	Ependymal glioma	almond		intact dissection	died 1 month later due to cicatrix in liter (autopsy)	—	r	(—)	1	High temperature (104.½ F). Responded fair[ly] well, answering some questions. Gradually lost strength and died 24 days after operation.		Cerebellar exploration 24 days prior to the operation.
6	" " Case 4		31	M	Ependymal glioma	25 gr.		intact dissection	well	6 mos.	r	l-small vein of Galen	1	Uneventful recovery. Discharged 13 days after operation. No mental after effect. Slightly increased loss of hearing for tones between 256 and 4096 in the left ear. Complete left homonymous hemianopia.	A definite left homonymous hemianopia.	
7	" " Case 5		24	F	Ependymal glioma	2 gr.		fragmentary removal	well	6 mos.	r	(—)	?	Uneventful. Discharged 18 days after operation. No improvement of vision.	No improvement of vision will be expected.	Totally blind before operation. Previously operated on elsewhere without success, a tumor.
8	" " Case 9		17	M	Adenoma of choroid plexus	pigeon's egg		intact dissection	died shortly after operation		r	(—)	1	Shortly after operation became cyanotic, respiration embarassed and died. No autopsy. The cause of death is probably postoperative hemorrhage.		
9	" " Case 10*		10	M	Combination of pineal and ependymal tumor	almond (3 gr)		tapping of cystic portion. Intact dissection of the remaining portion	well	6 mos.	r	(—)	(—)	Listless and voided in bed frequently. Transient blindness. A loss of hearing for the upper tones in both ears. Palsies of the right and left external rectus muscles disappeared. Discharged 19 days after operation, when visual field still constricted. No hemianopia.	Perfectly well and playing with other children 6 mos. later. 2½ years after operation, recurrence. Reoperation and death.	Cerebellar exploration preceded the operation.
10	" " Case 11		36	M	Pearly tumor	hickory nut		intracapsular curettage and removal of the capsule	died of pneumonia on the 4th day		r	(—)	3	Conscious the following morning. 48 hours after operation, temperature and respirations rose and on the fourth day died of pneumonia. Autopsy; no reason for any trouble from the cranial operation.		Cerebellar exploration 22 days prior to the operation.
11	" " Case 13		17	F	Cellular tumor, type unknown; prasibly of pineal origin.	pigeon's egg		intracapsular curettage and removal of the capsule	well	just left hospital	r	(—)	2	Uneventful. Discharged two weeks late.		Only case in Dandy's series in which the third ventricle was not actually opened during the operation.
12	" " Case 14		45	F	Verga's cyst or cyst of choroid plexus	bantam's egg		removal of the roof of cyst, and opening is made into the right lateral ventricle	well	3 mos.	r	(—)	0?	Uneventful. Vision much affected, doubtless from trauma to lateral geniculate bodies. [Hemi]anomous fields were more greatly impaired.	A definite impairment of vision	
13	Tönnis[14] Case 1		25	M	Ependymoma	?		removed intracapsularly by a suction machine	well	1 mos.	r	(—)	2	Widely dilated pupils do not react to light. 1 month later weakly reacts in accommodation. Still unsteady unsteady in gait. Walks with broad base.	No improvement of vision.	Totally blind before operation.
14	Allen-Lovell[115] Case 8		44	F	Ependymoma	marble		entirely removed	did not withstand the operation		?	?	?			
15	Allen-Lovell Case 4		7	M	Glioma	as large as to fill the IIIventricle		partial removal	died on the 2nd day		?	?	?			
16	Allen-Lovell Case 5		29	M	Ependymoma	walnut		completly excised	did not withstand the operation		?	?	?	Hyperthermia (107 F) and died.		
17	Dandy[81] 1931 Case 1		?	?	Tuberculoma of the pineal body	5×4cm	bilateral	intact dissection	died 5 mos. later presumably of other tubercles of the brain		l	(—)	several	Preoperative signs quickly disappeared. A weakness of the right side of the body for several days. No speech disturbance.		
18	Dandy[81] 1930 Case 3		15	M	Pinealoma	4gr.		intact dissection	well	2 mos.	r	r-small vein of Galen	?	Totally blind for 7 days. Vision steadily improved, but never completely. Transient hemiparesis. Extensive impairment of the extraocular muscles. Conjugate deviation of the eyes to the right. Elevation of the eyeballs and the upper lids poorly performed. Dilated pupils. Faint reaction to light.	Widely dilated pupils. React sluggishly to light. Failure of the left eye to converge. Almost abolished upper gaze. Left homonymous hemianopia.	On admission disoriented, extremely listless and talked incoherently.
20	Bailey[16] 1932 Case XLII		12	M	Teratoid	3×7cm		removal with electric loop	died 9 days after the IInd operation		r l l	?	l l several	After the 1st operation (removal of the right half of tumor); no subsequent hyperthermia. Unconscious. Migosis keeps sight and other brain syndrome. After the IInd operation (removal of the left half of tumor); high temperature (39–41°C). The eyes rolled constantly to the left with an occasional convergence spasm. Midbrain syndrome improved.		Temporal decompression was previously done.
21	Bailey[15] reported by Araki Case 1		57	F	Meningioma in the pineal region	3cm in diameter		removed with electric loop and a suction machine.	died 15 mos. after operation		l	(—)	several	Incontinent, incontinent and lethargic. Unable to move her eyes upward. 18 days later mentally clearer but peculiar and untidy. 49 days later could walk better, but still jocular and had a poor memory for recent events. Occasionally incontinent of urine at night. 11 months later definitely worse, disoriented and incontinent. Never complained of headache. Died 15 month later. No autopsy.	Mental disturbances. Incontinence	No disturbance of upward gaze before operation.
22	Bailey; repoted by Araki Case 2		44	M	Meningioma in the pineal region	4cm in diameter		main mass was removed by intact dissection, posterior portion of the tumor was left.	living but not very well	3 mos.	l	r-small vein of Galen	several	Temperature (39°C). Right homonymous hemianopia. Recovered 3 days later. 3 months (transient). 10 days later again high temperature (40°C), after operation, following an attack of influenza, walks well, very disoriented, indifferent and untidy. Incontinent. Poor memory for recent events.	r-homonymous hemianopia. Mental disturbances.	
23	Harris[83] and Cairus		20	M	Pinealoma	walnut		removed partly piecemeal and partly intact	recurred 9 mos. after operation. Improvement by X-ray treatment	14 mos.	r	(—)	several including Rolandic vein	Hemiparesis and hemihypesthesia. Eyes deviated to the right and downwards. Diplopia for 2 days. l-lower facial weakness for 10 days. Often drowsy. Vision impaired, l-homonymous hemianopia. A defect of postural sensibility on the left side of Limitation of upward gaze. the body. Astereognosis and impairment of tactile localization in the left hand. Incontinent. Poor memory for recent events. Unsteady in it.	l-hemianopia. Impairment of pectoral sensation. Pupils did not react to light. No convergence.	Cerebellar exploration 6 months previously.
24	Foerster[18] Case 1	tumors	25	M	Glioma	large plum 25gr.		piecemeal removal	well	5 mos.	r	(—)	several	Eyes deviated to the right (transient). Disturbed hearing diminished rapidly. 5 months after operation; no improvement. Other local signs completely disappeared.	No improvement of vision.	Totally blind before operation.
25	Foerster Case 2		17	M	Cystic tumor	mandarin		evacuation of cyst, partial removal of cyst wall	reucrrence 7 mos. later. Reoperation Death.		r	(—)	several	Hemianopia sinistra. All local and general sings diminished.	l-hemianopia. Recurrnce 7 months later. Reoperation. Death.	
26	Sachs[19]		20	M	Cystic tumor (cholesteatoma ?)	plum		removed	well	9 yrs.	r	?	?	Uneventful recovery. 2 weeks later temperature suddenly to 40.6°C. Rigidity of neck. Double Kernig's sign. 5,000 cells in spinal fluid. No organism detected. Laminectomy and drainage. Recovery.	No improvement of vision in the left eye.	The left eye blind before operation.
27	McLean[3]		0	M	Teratoma	2.1×1.8×2.0cm		removed totally in blocks	died soon after operation		l	(—)	4			
28	Tönnis[14] Case 2		5	?	Teratoma (cystic)	3.5×3cm		evacuation of cyst. Intact dissection of solid portion	well	6 mos.	l	(—)	2	Widely dilated pupils do not react to light. Limitation of upper gaze only suggested. Coodinate motion still poor. Gait staggering. 6 months later; light and dark perceived. No ataxia. No improvement of vision.	No improvement of vision.	Totally blind before operation.
29	Allen-Lovell[115] Case 6		13	M	Pinealoma	1.5cm in diameter		completely excised	well	2½ yrs.	r	?	?	Uneventful recovery. Unable to rotate the eyeballs upward following operation.	2½ years later seemed normal, except for a markedly leptosomatic appearance. Could rotate the eyes for a moment. Mentality not impaired.	
30	Allen-Lovell Case 7		19	M	Adenocarcinomatous teratoma	walnut		complete removal	died 2½ mos. later.		r?	?	?	A marked stupor for 14 days. Definite left hemiparesis. Unable to move the eyeballs upward following operation. Slow improvement. But suddenly died. Autopsy; degenerated cerebellum, quadrigeminum and extremely soft cerebrum.		
31	Van Wagenen[4]	Pineal	38	F	Pinealoma	3×3.5cm	Transcerebellar approach	removed with a rongeur and a suction machine. X-ray therapy after operation	well	15 mos.	r	(—)		Semicomatose. 2 days later drainage into the cortical vein was necessitated. Again comatose and high fever (39°–40°C.) for 5–6 days. Then semi-comatose. Homonymous hemianopia. Slight l-hemihypesthesia. From time to time astereognosis of the left hand. Mental disturbances. Incontinent for 2–3 weeks. A moderate depression for 2–3 months. Memory defect for recent events. Mental disturbances became so slight as to enable her to manage home work.	l-homonymous hemianopia. Slight mental disturbance.	10 months previously r-subtemporal decompression and X-ray treatment.
32	Horrax[86] 1936		42	F	Pinealoma	?		removed with a suction machine	well	2½ yrs.	r	(—)		Extremely stormy convalescence. Remitting temperature (104°F). Continued to lose ground for 14 months, then became conscious and rational. Vision failed considerably, gradually improved. 6 months later; partial contractures of both legs. Vision returned. Pupils reacted to light and in accommodation. Conjugate movements of the eyeballs restricted only to the slightest degree. Mental faculties unimpaired.	Partial contractures of legs.	Suboccipital exploration 4 weeks previously.
33	German[12] Case 1		?	?	Pinealoma ?	?		?	died 3½ mos. after operation							
34	German Case 2		?	?	Pinealoma ?	?		?	died on the 6th day after operation							
35	Dandy[81] 1936 Case 2		28	F	Pinealoma	15gr. (estimated)	Approach by resection of the occipital lobe.	fragmentary removal, largely by a suction machine	died 3 mos. after operation		r	Resection of sinus rectus and both small veins of Galen		Drowsy and listless for a number of days. Blind for several days, but vision gradually returned, l-homonymous hemianopia. All extraocular movements restricted, but not completely lost. Improved steadily. Disoriented for three weeks.	Incontinence. hemiparesis, hemihypesthesia. Sluggish mental State.	Decompression and X-ray treatment about 1 year ago. Improvement. Recurrence after 6 months. Again X-ray therapy without any effect.
36	Horrax[12] 1937		10	M	Pinealoma	8×4.5×3cm 70gr.		intact dissection	died 3 mos. after operation, presumably due to adhesion about midbrain		r	both small veins of Galen		High temperature (104.5°F) and drowsy for 3 days. Head and eyes were turned toward the left. Complete left hemiplegia and complete l-homonymous hemianopia. Pupils at first mydriatic but later myotic. Neither reacted to light. Incontinent. 7 weeks later; ocular movements unrestricted, including conjugate upward movements. l-hemihypesthesia for pinprick and deep muscle pain. Sluggish mental state.		

* Apparently the same as case 1 in 8).

Sixteen cases of tumors of the third ventricle which were removed dy the pineal approach are included in our series. Of these five died immediately after operation, one died in the later postoperative course, thus the total operative deaths in six cases making a 37.5% operative mortality. Another died of recurrence two and one half years later. In three cases the operation was very successful, the patients surviving for more than two years and the other six had been living and well at the time when they were reported, although it was within two years after operation.

Between tumors of the pineal body and those of the third ventricle, there is no definite difference in the operative results, except that more deaths occurred at later stage of the post-operative course in the former group.

In both pineal and third ventricle tumors the following sequels were noticed after operation : Extrinsic and intrinsic ocular muscle palsies in thirteen cases, mental disturbances in twelve, contralateral hemiparesis in ten, contralateral homonymous hemianopia in nine, disturbance of visual acuity in seven, hyperthermia in seven, incontinence of urine in six, contralateral hemihypesthesia, astereognosis, loss of position sense in five, loss of hearing for high tones in two and decerebrate rigidity in one. Almost all these sequels were transient, except in the case of ocular muscle palsies and hemianopia.

Reviewing these facts, several points in regard to the operative technique were discussed.

i. No more of the superior cerebral veins should be sacrificed than absolutely necessary.

ii. The sacrifice of the great vein and both small veins of Galen does not necessarily mean the death of the patient, but is inadvisable.

iii. One small vein of Galen can be ligated and divided without endangering the life of the patient.

iv. The approach from the left side for right-handed patients need not be much feared.

v. The tumor should be removed, whenever possible, by a suction machine, or by intra-capuslar excavation, with subsequent dissection of its outer portion.

Table II.

Operative Results in Cases of Table I.

		Total cases	Died within 10 days after operation	Died 1–6 months after operation	Died later than 6 months after operation	Total deaths	Survived, living and well for more than 2 years	Survived, living and well but less than two years had elapsed since operation at the time of report
Tumors of the third ventricle	Unilateral posterior transcallosal approach	16	5	1	1	7	3	6
Pineal tumors	Unilateral posterior transcallosal approach	14	3	1	3	7	2	5
	Trans-ventricular approach	4	1	1	0	2	1	1
	Approach by resection of occipital lobe	2	0	2	0	2	0	0
	Total of pineal tumors	20	4	4	3	11	3	6
Total		36	9	5	4	18	6	12

Foot note to Table I.

13) Dandy, W. E. Benign tumors in third ventricle of the brain: Diagnosis and treatment. C. Thomas, Springfield, Illinois, 1933.

14) Tönnis, W. Behandlung der Geschwülste in hinteren Teil des 3. Ventrikels. Arch. f. Klin. Chir. 1935, **183**, 426–429.

15) Allen, S. S. and Lovell, H. W. Tumors of the third ventricle. Arch. Neurol. & Pyschiat. 1932, **28**, 990–1006.

16) Bailey, P. Intracranial tumors. C. Thomas, Springfield, Illinois. 1933, pp. 334–336.

17) Araki, C. Meningioma in the pineal region. A report of two cases, removed by operation. Arch. f. Jap. Chir. 1937, **14**.

18) Harris, W. and Cairns, H. Diagnosis and treatment of pineal tumors. With report of a case. Lancet I 1932, 3–9.

19) Sachs, E. Diagnosis and treatment of brain tumors. St. Louis: C. V. Mosby Co., 1930, p. 276.

20) Horrax, G. Further observations on tumor of the pineal body. Arch. Neurol. & Psychiat. 1936, **35**, 215–226.

Table. I. Tumors of the pineal body

No.	Case operated on by	Location of tumor	Age	Sex	Nature of tumor	Size of tumor	Operative approach	Method of removal	Result
1	Dandy[13] 1933 Group I Case 1	Tumors in the third ventricle	24	F	Colloidcyst	marble	unilateral posterior transcallosal approach	intact dissection	well
2	" " " Case 2		34	F	Colloidcyst	marble		evacuation of cyst. removal of capsule	well
3	" " " Case 5		37	F	Colloidcyst	marble		intact dissection	well
4	Dandy 1933 Group II Case 2		6	F	Ependymal glioma	almond		intact dissection	well
5	" " " Case 3		12	M	Ependymal glioma	almond		intact dissection	died 1 month later due to cicatrix in iter (autopsy)
6	" " " Case 4		31	M	Ependymal glioma	25 gr.		intact dissection	well
7	" " " Case 5		24	F	Ependymal glioma	2 gr.		fragmentary removal	well
8	" " " Case 9		17	M	Adenoma of choroid plexus	pigeon's egg		intact dissection	died shortly after operation
9	" " " Case 10*		10	M	Combination of pineal and ependymal tumor	almond (3 gr)		tapping of cystic portion. intact dissection of the remaining portion	well
10	" " " Case 11		36	M	Pearly tumor	hickory nut		intracapsular curettage and removal of the capsule	died of pneumonia on the 4th day
11	" " " Case 13		17	F	Cellular tumor, type unknown; possibly of pineal origin.	pigeon's egg		intracapsular curettage and removal of the capsule	well
12	" " " Case 14		45	F	Verga's cyst or cyst of choroid plexus	bantam's egg		removal of the roof of cyst, and opening is made into the right lateral ventricle	well
13	Tönnis[14] Case 1		25	M	Ependymoma	?		removed intracapsularly by a suction machine	well
14	Allen-Lovell[15] Case 8		44	F	Ependymoma	marble		entirely removed	did not withstand the operation
15	Allen-Lovell Case 4		7	M	Glioma	as large as to fill the IIIventricle		partial removal	died on the 2nd day
16	Allen-Lovell Case 5		29	M	Ependymoma	walnut		completly excised	did not withstand the operation
17	Dandy[5] 1921 Case 1		?	?	Tuberculoma of the pineal body	5×4cm		intact dissection	died 8 mos. later presumably of other tubercles of the brain